AN ANNOTATED BIBLIOGRAPHY OF THE DOUGLAS-FIR BEETLE (*DENDROCTONUS PSEUDOTSUGAE* HOPKINS)

Compiled by
Malcolm M. Furniss and Robert D. Oakes

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INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
Ogden, Utah 84401

THE AUTHORS

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ABSTRACT

Annotates the contents of 203 published references. Citations are cross-referenced by subject as well as by author.

OXFORD: 411:4. KEYWORDS: Douglas-fir beetle, annotated bibliography, biological control, forest insect ecology, forest protection, insect pheromones.

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FOREWORD

The Douglas-fir beetle is one of the more destructive bark beetles in the West. After catastrophic disturbances, such as windthrow and fire, it breeds in the damaged host trees and may then kill millions of board feet of live timber. Infestations may persist in interior stands for several years, evidently aided by drought and other predisposing factors.

This Bibliography is complete through 1972. The references are indexed by author and subject. To avoid duplication, we have arbitrarily included only what we consider to be published references; thus, theses and some processed reports, such as the Proceedings of the Western Forest Insect Work Conference, are not listed. We also arbitrarily omitted references concerning insects that may occur with the Douglas-fir beetle if those references did not mention or deal significantly with the Douglas-fir beetle. For example, if the clerid, Enoclerus sphegeus Fab., were to be published on only in relation to the mountain pine beetle, it would not be included here. We also have not listed some published references that we believe to be of minor importance or that appear in essence in references included in this Bibliography. We have not listed annual reports of research agencies and annual insect conditions reports.

BIBLIOGRAPHY

1. ANONYMOUS. 1971. Douglure: a powerful tool in manipulating the Douglas-fir beetle. South. For. Res. Inst. Prog. Rep., May-June, 1971:11-12.

In Idaho, 147 live trees were baited with a mixture of frontalin, camphene, and α-pinene. By late June, these trees, and 480 nearby, had been attacked by beetles.

2. ALLEN, DONALD G., ROBERT R. MICHAEL, and SOLON A. STONE. 1958. Sounds of Douglas fir beetle activity. Oreg. For. Lands Res. Cent., Corvallis, Res. Note 36, 19 p.

Behavior of beetles in their natural habitat was inferred from their sounds. Stridulation and boring activities were monitored with sound-amplifying and recording equipment. Characteristics of these sounds were analyzed using an oscilloscope.

3. ALLEN, D. G., and J. A. RUDINSKY. 1959. Effectiveness of Thiodan, Sevin, and lindane on insects attacking freshly cut Douglas-fir logs. J. Econ. Entomol. 52:482-484.

Douglas-fir beetle attacks were unsuccessful on all logs treated with 3 pounds of active ingredient to 100 gallons of water 19 weeks after treatment, except Sevin-treated logs had 0.1 successful attack per sq.ft. Treatments using 1 lb. per 100 gal. of water were less protective.

4. ATKINS, M. D. 1957. A study of the effect of nematodes and mites on Douglas-fir beetle flight. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 13(5):2-3.

Infestation by nematodes and mites had no effect on flight response and duration.

5. ATKINS, M. D. 1959. A method for the close-up photography of insect behavior. Can. Entomol. 91:328-329.

The Douglas-fir beetle was used to demonstrate how insect behavior may be studied photographically if a few basic reactions of an insect are known (e.g., the beetle's tendency to walk up an incline toward light and into a flow of air before preparing to fly).

6. ATKINS, M. D. 1959. A study of the flight of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. (Coleoptera: Scolytidae). I. Flight preparation and response. Can. Entomol. 91:283-291.

Infestation of beetles by mites and nematodes did not affect the beetles' flight behavior; however, light intensity and temperature did. Females lost their ability or inclination to fly after start of gallery construction. Males did not entirely lose their positive response.

7. ATKINS, M. D. 1960. A study of the flight of the Douglas-fir beetle *Dendroctonus pseudotsugae* Hopk. (Coleoptera: Scolytidae). II. Flight movements. Can. Entomol. 92:941-954.

Wing-beat amplitude and frequency were characterized and studied in relation to infestation by mites and nematodes, temperature, humidity, light, atmospheric pressure, and fatigue.

8. ATKINS, M. D. 1961. A study of the flight of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. (Coleoptera: Scolytidae). III. Flight capacity. Can. Entomol. 93:467-474.

Describes study of duration, and to a lesser extent, velocity, in relation to presence of mites and nematodes, physical factors, and history of beetle (i.e., spring-emerged vs. reemerged). Velocities on flight mills were compared to those in free flight.

9. ATKINS, M. D. 1966. Behavioural variation among scolytids in relation to their habitat. Can. Entomol. 98:285-288.

A philosophical thesis correlating various behavior to temporary habitat; the Douglas-fir beetle is cited incidentally.

10. ATKINS, M. D. 1966. Laboratory studies on the behaviour of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins. Can. Entomol. 98:953-991.

Exhaustive study of the relationships between beetle response to physical factors and their subsequent response to host logs. Response to host varied with fat content; those having less fat were host-positive, others were host-negative.

11. ATKINS, M. D. 1966. Studies on the fat content of the Douglas-fir beetle. Can. Dep. For. Bimon. Res. Notes 22(4):3.

Highest fat content was found in beetles that (a) had not flown, (b) had developed under cool conditions, and (c) were not crowded during development.

12. ATKINS, MICHAEL D. 1967. The effect of rearing temperature on the size and fat content of the Douglas-fir beetle. Can. Entomol. 99:181-187.

Temperature influenced rate of development, brood size, and fat content. Fat content of adults declined during the overwintering period. Suggests that amount of change in fat content depends upon the duration of activity periods, diapause, and the feeding and metabolism rates. Because these processes are controlled by temperature, the prediction of population quality and behavior requires a thorough understanding of the effects of weather differences on bark beetle broods.

13. ATKINS, M. D. 1968. Scolytid pheromones--ready or not. Can. Entomol. 100: 1115-1117.

Discusses the built-in dangers of using bark-beetle pheromones without conclusive knowledge of the biology, behavior, and genetics of the species to be managed.

14. ATKINS, MICHAEL D. 1969. Lipid loss with flight in the Douglas-fir beetle. Can. Entomol. 101:164-165.

Beetles flown on flight mills showed considerable fat loss when compared to similar beetles from an unflown control group.

15. ATKINS, M. D., and J. A. CHAPMAN. 1957. Studies on nervous system anatomy of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. (Scolytidae). Can. Entomol. 89:80-86.

Describes the main anatomical features of the adult beetle nervous sytem. Unusual features include variation in origination and branching of abdominal nerve trunks and the rather posterior position of the frontal ganglion relative to the brain.

16. ATKINS, M. D., and S. H. FARRIS. 1958. A technique for measuring flight muscle changes in the Douglas-fir beetle, *Dendroctonus pseudotsugae*. Can. Dep. Agric., For. Biol. Div. Sci. Serv. Bimon. Prog. Rep. 14(4):3-4.

Presents procedures for preparing serial sections of flight muscles to measure changes during degeneration and regeneration.

17. ATKINS, M. D., and S. H. FARRIS. 1962. A contribution to the knowledge of flight muscle changes in the Scolytidae (Coleoptera). Can. Entomol. 94:25-32.

Flight muscles of male and female Douglas-fir beetles degenerated during either brood establishment or starvation. Females' muscles degenerated about 15 days sooner than the males' muscles. Conditions correlated with degeneration included narrowing and displacement of muscle bundles, loss of evident striations, and intrusion of fat bodies into the muscle area. The space and/or substance of their flight muscles may be utilized during periods when flight dispersal is not required.

18. ATKINS, M. D., and L. H. McMULLEN. 1958. Selection of host material by the Douglas-fir beetle. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 14(1):3.

Beetles attacked log sections lying on the ground much more intensely than sections set upright. Authors speculate that this could be attributed to (a) easier landing and (b) differences in heating by the sun.

19. ATKINS, MICHAEL DONALD, and L. H. McMULLEN. 1960. On certain factors influencing Douglas-fir beetle populations. Fifth World For. Congr. Proc., Seattle, Wash. 2:857-859.

Illustrates how beetle populations are affected by weather, preference for certain host material, and resulting competition.

20. BEDARD, W. D. 1933. The number of larval instars and the approximate length of the larval stadia of *Dendroctonus pseudotsugae* Hopk., with a method for their determination in relation to other bark beetles. J. Econ. Entomol. 26: 1128-1134.

First and second instar larvae were reared on inner bark between two glass plates. When Dyar's law was applied to their head width measurements, it indicated [erroneously][1] five instars. Duration of stadia was determined using Taylor's method.

21. BEDARD, WILLIAM DELLES. 1937. Biology and control of the Douglas-fir beetle *Dendroctonus pseudotsugae* Hopkins (Coleoptera-Scolytidae) with notes on associated insects. Wash. State Coll. Res. Stud. 5:103-105. (Abstr.)

Ph.D. dissertation on biology, natural enemies, and associates. Parasites and predators accounted for 89.2% brood mortality, mainly in the egg and larval stages.

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[1]Comments in brackets are those of the authors of the bibliography.

22. BEDARD, W. D. 1938. An annotated list of the insect fauna of Douglas-fir (*Pseudotsuga mocronata* Rafinesque) in the northern Rocky Mountain region. Can. Entomol. 70:188-197.

Lists 153 insect species associated with the tree. Brief annotations refer to habitat, relationships to the beetle, and seasonal history.

23. BEDARD, W. D. 1950. The Douglas-fir beetle. U.S. Dep. Agric. Circ. 817, 10 p.

Describes biology, seasonal history, infestation characteristics, ecological relationships, and control. [Needs updating.]

24. BELLUSCHI, P. G., and NORMAN E. JOHNSON. 1969. The rate of crown fade of trees killed by the Douglas-fir beetle in southwestern Oregon. J. For. 67:30-32.

Yearly weather patterns determined the rate of crown fade of beetle-killed Douglas-fir. In a wet and cool year, one-fourth to one-third of the trees had faded by fall; in a dry year, two-thirds were faded.

25. BELLUSCHI, P. G., NORMAN E. JOHNSON, and H. J. HEIKKENEN. 1965. Douglas-fir defects caused by the Douglas-fir beetle. J. For. 63:252-256.

Many attacked trees survive but the unsuccessful egg galleries are grown over and become defects that affect product quality.

26. BENNETT, ROY B., and JOHN H. BORDEN. 1971. Flight arrestment of tethered *Dendroctonus pseudotsugae* and *Trypodendron lineatum* (Coleoptera: Scolytidae) in response to olfactory stimuli. Ann. Entomol. Soc. Am. 64:1273-1286.

Tethered male Douglas-fir beetles stopped flying in response to odors of female frass. Response occurred only after previous flight exercise. Females did not respond to frass, but both males and females were arrested by phloem odors. Before flight, beetles swallowed air, which may be a pressure-sensory mechanism related to observation that beetles flew well only on clear days.

27. BORDEN, JOHN H., and R. B. BENNETT. 1969. A continuously recording flight mill for investigating the effect of volatile substances on the flight of tethered insects. J. Econ. Entomol. 62:782-785.

Describes operation of a rotary flight mill and photocell-ratemeter-paperchart recorder. Flying male Douglas-fir beetles ceased flight abruptly when sex pheromone (female frass) was introduced into the flight chamber.

28. BORDEN, JOHN H., and M. McCLAREN. 1970. Biology of *Cryptoporus volvatus* (Peck) Shear (Agaricales, Polyporaceae) in southwestern British Columbia: distribution, host species, and relationship with subcortical insects. Syesis 3:145-154.

During the year after trees are attacked by Douglas-fir beetles, *C. volvatus* hyphae extrude through holes made by the beetles and develop sporophores. Circumstantially, the predator *Temnochila virescens* var. *chlorodia* (Mann.) is suggested as a likely vector.

29. BORDEN, JOHN H., R. M. SILVERSTEIN, and R. G. BROWNLEE. 1968. Sex pheromone of *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae): production, bio-assay, and partial isolation. Can. Entomol. 100:597-603.

Attractiveness of frass increased up to 8 hr. after attack, then declined but was substantially renewed when females reemerged and attacked again. Extracts and distillates

of frass were attractive; response increased greatly with increased concentration. Response to combinations of fractions indicated a three-way synergism but the most attractive component was contained in one fraction.

30. BUSHING, RICHARD W. 1965. A synoptic list of the parasites of Scolytidae (Coleoptera) in North America north of Mexico. Can. Entomol. 97:449-492.

Hymenopterous parasites of the Douglas-fir beetle include species of *Coeloides, Campoplex, Cecidostiba, Cheiropachus, Tomicobia* [misidentification, see Furniss, M. M., 1968, p. 1388] and *Roptrocerus*. Also discusses briefly various scolytid parasites in regard to their morphology, seasonal history, host-tree selection, parasitism, importation and colonization, and the importance of controlling their beetle hosts.

31. CHAMBERLIN, W. J . 1918. Bark-beetles infesting the Douglas-fir. Oreg. Agric. Exp. Stn. Bull. 147, 40 p.

Illustrates unidentified parasite [*Coeloides brunneri*]; lists the following mites as possible predators: *Seius safroi* Ewing, *Bdella magna* Ewing, and a species of Gamassidae. Other predators mentioned are *Clerus sphegens* Fabr. [*Enoclerus sphegeus*], *Cicndella longilabris* Say, *Dasyllis posticata* Say, and *Dasyllis* sp.?. [Technically outdated but of historical value.]

32. CHAMBERLIN, W. J. 1939. The bark and timber beetles of North America. Oreg. State Coll. Coop. Assoc., Corvallis. 513 p.

Mites claimed to be associated with Douglas-fir beetle (p. 67-68) include *Pediculoides ventricosus, Seius safroi* Ewing, and *Bdella magna* Ewing (in mines).

33. CHAMBERLIN, W. J. 1958. The Scolytoidea of the Northwest. Oregon, Washington, Idaho, and British Columbia. Oreg. State Coll., Corvallis, Oreg. State Monogr. 2, 208 p.

Briefly discusses aspects of the beetle, including habits, seasonal history, and biology.

34. CHANSLER, JOHN F. 1968. Douglas-fir beetle brood densities and infestation trends on a New Mexico study area. USDA For. Serv. Res. Note RM-125, 4 p.

During 1959-64, average numbers of adult beetles just prior to flight (May) appeared to be correlated with numbers of trees attacked after emergence. Variance in brood numbers between trees was greater at 5 ft. than at 10 ft. aboveground.

35. CHANSLER, JOHN F., and DONALD A. PIERCE. 1966. Bark beetle mortality in trees injected with cacodylic acid (herbicide). J. Econ. Entomol. 59:1357-1359.

Douglas-fir beetle broods were reduced 87% by injecting trees with cacodylic acid shortly after attack.

36. CHAPMAN, J. A. 1954. Flight of *Dendroctonus pseudotsugae* in the laboratory. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 10(4):4.

Beetles attached to rotating mills flew continuously up to 9 hr. at velocities of 30-40 meters per min. Additional flights occurred.

37. CHAPMAN, J. A. 1955. Ingestion of paper and vegetables by the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 11(2):4.

Callow beetles were fed various paper substances, fruits, and vegetables to determine the nutritional value of the materials. A portion of each material was ingested but amounts varied among the beetles. The amount consumed was never as great as normal feeding in bark.

38. CHAPMAN, J. A. 1955. Sex determination by stridulation sounds in the Douglas-fir beetle, *Dendroctonus pseudotsugae*. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 11(3):2.

Sexing of live beetles by sound of male stridulation was done rapidly and did not harm them. When combined with feeling the roughness of the elytral declivity this method was almost 100 percent accurate, even with callow adults.

39. CHAPMAN, J. A. 1963. Field selection of different log odors by scolytid beetles. Can. Entomol. 95: 673-676.

Scolytid beetles responded to four different log odors released from test boxes. *Dendroctonus pseudotsugae* was attracted only to Douglas-fir odors.

40. CHAPMAN, J. A. 1966. The effect of attack by the ambrosia beetle *Trypodendron lineatum* (Olivier) on log attractiveness. Can. Entomol. 98: 50-59.

Douglas-fir beetles did not respond to "secondary attraction" from *Trypodendron* boring in the test logs.

41. CHAPMAN, J. A. 1967. Response behaviour of scolytid beetles and odour meteorology. Can. Entomol. 99:1132-1137.

Suggests that transport and dispersal of odors by air currents is an important factor in scolytid response to attractant sources. Knowledge of odor meteorology would increase effectiveness of attractants and repellents in scolytid control.

42. CHAPMAN, J. A., and E. D. A. DYER. 1969. Cross attraction between the Douglas-fir beetle [*Dendroctonus pseudotsugae* Hopk. and the spruce beetle *D. obesus* (Mann.)]. Can. Dep. Fish. and For., For. Serv., Bimon. Res. Notes 25(4):31.

Field populations of flying Douglas-fir beetles or spruce beetles responded similarly to females of either beetle species in either white spruce or Douglas-fir.

43. CHAPMAN, JOHN A., and JAMES M. KINGHORN. 1955. Window flight traps for insects. Can. Entomol. 87:46-47.

Glass barrier traps were used to sample flying populations of scolytids. Douglas-fir beetle was the fourth most numerous scolytid species caught.

44. CHAPMAN, J. A., and J. M. KINGHORN. 1958. Studies of flight and attack activity of the ambrosia beetle, *Trypodendron lineatum* (Oliv.), and other scolytids. Can. Entomol. 90:326-372.

Douglas-fir beetles showed the greatest flight and attack activity during May.

45. CHAPMAN, J. A., and J. W. WILSON. 1956. The use of impregnated paper as an approach to nutritional studies with the Douglas-fir beetle. J. Econ. Entomol. 49:426-427.

Seven carbohydrates were added to chemically-defined papers to study food requirements of adult beetles. Conclusions regarding carbohydrate preference were difficult because the beetles did not readily ingest the papers.

46. CORNELIUS, ROYCE O. 1955. How forest pests upset management plans in the Douglas-fir region. J. For. 53:711-713.

The Douglas-fir beetle killed 3.5 billion bd.ft. of timber in Oregon during 1950-1954. As a result of the dead timber, management development plans were disrupted, allowable cut was exceeded, and fire hazard was increased.

47. COWAN, B. D., and W. P. NAGEL. 1965. Predators of the Douglas-fir beetle in western Oregon. Oreg. State Univ., Agric. Exp. Stn. Tech. Bull. 86, 32 p.

Of six clerids studied, *Enoclerus sphegeus* Fab. was most prevalent and effective against the Douglas-fir beetle. Three species (*Thanasimus undatulus* Say, *E. lecontei* Wolcott, and *Enoclerus* sp.) were questionably associated with the Douglas-fir beetle; two species (*E. schaefferi* and *E. eximus*) were not. Considerable information is given on life history and abundance of *E. sphegeus*; less information is given for the other species.

48. DYER, E. D. A., and J. A. CHAPMAN. 1965. Flight and attack of the ambrosia beetle, *Trypodendron lineatum* (Oliv.) in relation to felling date of logs. Can. Entomol. 97:42-57.

Among logs felled over a 10-month period, Douglas-fir beetles responded strongest to those felled during late winter and early spring.

49. DYER, E. D. A., J. P. SKOVSGAARD, and L. H. McMULLEN. 1968. Temperature in relation to development rates of two bark beetles. Can. Dep. For. & Rural Dev., For. Br., Bimon. Res. Notes 24(2):15-16.

Douglas-fir beetle brood developed fastest at the highest of four constant temperatures (62°, 52°, 49°, 43° F.). Its threshold temperature for development (43°-49° F.) was higher than that of the spruce beetle.

50. EVENDEN, JAMES C., and KENNETH H. WRIGHT. 1955. Douglas-fir beetle. USDA For. Serv., For. Pest Leafl. 5, 4 p.

Gives general information on the Douglas-fir beetle, including some control methods. [Superseded by Furniss and Orr 1970.]

51. FANG, S. C., and DON ALLEN. 1955. Distribution and incorporation of radioactive phosphorus in the Douglas-fir beetle. J. Econ. Entomol. 48:79-82.

Beetles were fed radioactive phosphorus after which the percent radioactivity of five parts of the body was determined. Presents the relative amounts of P_{32} contained by compounds; carbohydrates had most, fat had little.

52. FARRIS, S. H. 1965. A preliminary study of mycangia in the bark beetles, *Dendroctonus ponderosae* Hopk., *Dendroctonus obesus* Mann., and *Dendroctonus pseudotsugae* Hopk. Can. Dep. For., For. Entomol. and Pathol. Br., Bimon. Prog. Rep. 21(5):3-4.

Only 1 of 25 teneral adult female Douglas-fir beetles had fungoid material, which was in the coxal cavities and integumental folds of the scutellum.

53. FITZGERALD, T. D., and W. P. NAGEL. 1970. Preemergence orientation of *Medetera aldrichii* (Diptera: Dolichopodidae). Ann. Entomol. Soc. Am. 63:913-914.

Prior to pupation, larvae of *Medetera aldrichii* aggregate near openings to the outer bark. Laboratory tests indicated that light entering the openings was the cause of larval aggregation. Formation of pupae cells near openings facilitates the subsequent migration of photopositive pupae to the bark surface where adults eclose.

54. FITZGERALD, T. D., and W. P. NAGEL. 1972. Oviposition and larval bark-surface orientation of *Medetera aldrichii* (Diptera: Dolichopodidae): Response to a prey-liberated plant terpene. Ann. Entomol. Soc. Am. 65:328-330.

Female *Medetera aldrichii* laid eggs near Douglas-fir beetle entrances and ventilation holes. Emanation of a volatile compound, such as D-alpha-pinene, from prey galleries may stimulate oviposition and guide newly eclosed predator larvae toward prey gallery openings.

55. FURNISS, MALCOLM M. 1959. Reducing Douglas-fir beetle damage--how it can be done. USDA For. Serv., Intermt. For. & Range Exp. Stn. Res. Note 70, 6 p.

Brief discussion of biology, infestation characteristics, and recommendations for preventing or lessening damage.

56. FURNISS, M. M. 1962. A circular punch for cutting samples of bark infested with beetles. Can. Entomol. 94:959-963.

Describes construction and operation of a 1/10-sq.ft. circular punch used to sample Douglas-fir beetle populations. Discusses advantages of the punch and compares its efficiency to that of larger sampling units.

57. FURNISS, MALCOLM M. 1962. Infestation patterns of Douglas-fir beetle in standing and windthrown trees in southern Idaho. J. Econ. Entomol. 55:486-491.

Describes characteristic infestation zones in standing and windthrown trees as an aid to efficient population sampling.

58. FURNISS, MALCOLM M. 1962. Effectiveness of DDT for preventing infestation of green logs by the Douglas-fir beetle. USDA For. Serv., Intermtn. For. & Range Exp. Stn. Res. Note 96, 10 p.

Numbers of egg galleries and progeny resulting in green logs were reduced significantly by application of a 2% DDT emulsion spray before beetles attacked. Discusses methods to evaluate effectiveness of the spray.

59. FURNISS, MALCOLM M. 1964. A method to determine progressive mortality during seasonal development of Douglas-fir beetle brood. J. Econ. Entomol. 57:178-180.

Use of a bark punch and the replacement of samples after counting permitted sampling of the same trees at four different times, which reduced between-tree variations. Mortality was high and variable early in the life of the brood. Relatively small changes occurred overwinter. Makes comparisons between north and south sides of stems and between two generations.

60. FURNISS, MALCOLM M. 1965. Susceptibility of fire-injured Douglas-fir to bark beetle attack in southern Idaho. J. For. 63:8-11.

Fire injury made trees susceptible to a high incidence of beetle attack; attacks increased with tree size and severity of injury, up to but not including the death of the trees. However, attack density, rate of brood establishment (success of attack), and length of infested stem were abnormally low, due possibly to abundance of injured trees and low beetle population.

61. FURNISS, MALCOLM M. 1965. An instance of delayed emergence of the Douglas-fir beetle and its effect on an infestation in southern Utah. J. Econ. Entomol. 58:440-442.

Documents the abrupt termination of a long term infestation when the brood remained in infested trees for two winters. The proportions of brood stages entering fall became progressively more immature over a 4-year period before the decline, apparently because of cool weather.

62. FURNISS, MALCOLM M. 1967. Nematode parasites of the Douglas-fir beetle in Idaho and Utah. J. Econ. Entomol. 60:1323-1326.

Ectoparasites of the beetle included *Mikoletzkya* sp. (mostly), *Ektaphelencus obtusus* Massey, and *Aphelenchoides* sp. Endoparasites were: *Contortylenchus reversus* (Thorne) Rühm, *Parasitaphelenchus* sp. (both in the body cavity), and *Parasitorhabditis obtusa* (Fuchs) Dougherty (in the midgut). Parasitism rates varied little by sex of beetle; greater differences occurred between (a) localities, (b) standing and felled trees, and (c) beetles of different maturity.

63. FURNISS, MALCOLM M. 1968. Notes on the biology and effectiveness of *Karpinskiella paratomicobia* parasitizing adults of *Dendroctonus pseudotsugae*. Ann. Entomol. Soc. Am. 61:1384-1389.

Records the first known insect parasite of any adult *Dendroctonus* species. *K. paratomicobia* was found only in Utah and Arizona. Parasitized beetles laid fewer eggs and constructed shorter galleries. The parasite may lessen competition among beetle brood and increase their survival.

64. FURNISS, M. M., L. N. KLINE, R. F. SCHMITZ, and J. A. RUDINSKY. 1972. Tests of three pheromones to induce or disrupt aggregation of Douglas-fir beetles in live trees. Ann. Entomol. Soc. Am. 65:1227-1232.

Trees baited with frontalin were attacked, but mostly unsuccessfully, and few beetles were trapped. 3-methyl-2-cyclohexen-1-one disrupted attraction and may be useful for preventing attack. The role of *trans*-verbenol was not clear.

65. FURNISS, M. M., and P. W. ORR. 1970. Douglas-fir beetle. USDA For. Serv., For. Pest Leafl 5 Rev., 4 p.

Summarizes the beetle's geographic range, hosts, damage caused, infestation symptoms, description of stages, and seasonal history and control.

66. FURNISS, M. M., and R. F. SCHMITZ. 1971. Comparative attraction of Douglas-fir beetles to frontalin and tree volatiles. USDA For. Serv., Res. Pap. INT-96, 16 p.

Among 30 treatments, log sections infested with 50 virgin females were most attractive, followed by frontalin with resin and frontalin with α-pinene. More males than females responded. Data on 26 other insects, including a new species of *Hylurgops*, are included.

67. FURNISS, R. L. 1936. Bark beetles active following Tillamook fire. Timberman 37(3):21-22.

Although not normally destructive in coastal stands, Douglas-fir beetles bred in fire-injured trees after which they killed trees adjacent to the burn area.

68. FURNISS, R. L. 1941. Fire and insects in the Douglas-fir region. U.S. For. Serv., Fire Control Notes 5:211-213.

During the year after the Tillamook burn, Douglas-fir beetles bred in fire injured trees. In the second and third years, they killed 200 million bd.ft. of green timber.

69. GIBSON, ARCHIE L. 1957. Tests of bark-penetrating insecticides to control the Douglas-fir beetle. J. Econ. Entomol. 50:266-268.

Orthodichlorobenzene, trichlorobenzene, and dichloroethyl ether in oil and ethylene dibromide in oil or emulsified in water killed broods in logs and trees. Wet bark lowered the kill. Use of emulsion spray would reduce transportation costs.

70. HAGEN, K. S., and L. E. CALTAGIRONE. 1968. A new nearctic species of *Karpinskiella*. Pan-Pac. Entomol. 44:241-248.

Describes *K. paratomicobia*, the only known insect parasite of any adult *Dendroctonus* species (*D. pseudotsugae* Hopk.).

71. HAGENSTEIN, W. D., and R. L. FURNISS. 1956. Cooperation speeds salvage of windthrown and beetle-killed timber in Oregon and Washington. Soc. Am. For. Proc., 1955:167-168.

Wind and beetles killed 15 billion bd.ft. of Douglas-fir timber during 1951-1954. The Northwest Forest Pest Action Committee organized a cooperative detection survey which provided information to assist salvage operations. Two and one-half billion bd.ft. were salvaged by December 1954, and operations were continuing.

72. HANOVER, J. W., and M. M. FURNISS. 1966. Monoterpene concentration in Douglas-fir in relation to attack by the Douglas-fir beetle. P. 23-28, in: 2nd Genet. Workshop, Soc. Am. For., and 7th Lake States For. Tree Improv. Conf. Joint Proc., Oct. 21-23, 1965. U.S. For. Serv. Res. Pap. NC-6.

Reports the identity and relative concentration of 6 monoterpenes of inland Douglas-fir. The influences of season, tree characteristics, viscosity, and locality on monoterpenes were investigated. Concentration of myrcene and an unknown monoterpene differed between unattacked trees and trees that resisted attack.

73. HARWOOD, W. G., and J. A. RUDINSKY. 1966. The flight and olfactory behavior of checkered beetles (Coleoptera: Cleridae) predatory on the Douglas-fir beetle. Oreg. State Univ., Agric. Exp. Stn. Tech. Bull. 95, 36 p.

Describes the environmental conditions that accompany flight of *Enoclerus sphegeus*, *E. lecontei*, and *Thanasimus undatulus*. Response of these predators to vapors of oleoresins and monoterpenes is reported and discussed.

74. HEIKKENEN, HERMAN J., and BJORN F. HRUTFIORD. 1965. *Dendroctonus pseudotsugae*: A hypothesis regarding its primary attractant. Science 150:1457-1459.

The hypothesis states that beetles are attracted to host trees by α-pinene but repelled by β-pinene. Proportion of monoterpenes is suggested as a mechanism involved with beetle susceptibility.

75. HOPKINS, A. D. 1921. Contributions toward a monograph of the scolytid beetles. I. The genus *Dendroctonus*. 1909. II. Preliminary classification of the superfamily Scolytoidea. 1915. USDA, Bur. Entomol. Tech. Ser. 17, Part I, p. 1-164; Part II, p. 165-247.

Contains description of adult, pupa, larva, galleries, distribution, and hosts. Though often overlooked, this is the original reference to secondary sex characters on the penultimate tergite (p. 36-37) and elytral declivity (p. 121).

76. HOPPING, GEORGE R. 1932. Control of Douglas-fir bark beetles. Timberman 33(7):61.

Contains recommendations to reduce amount of timber lost to bark beetles in logging operations.

77. HOPPING, GEORGE R. 1942. Apparent negative geotropism in the Douglas fir bark beetle. Can. Entomol. 74:205.

Adult Douglas-fir beetles showed negative geotropism (i.e., tunneled upward) in felled trees on 15° or steeper slopes.

78. HOPPING, GEORGE R. 1947. Notes on the seasonal development of *Medetera aldrichii* Wheeler (Diptera; Dolichopidae) as a predator of the Douglas-fir bark-beetle *Dendroctonus pseudotsugae* Hopkins. Can. Entomol. 79:150-153.

Describes the life cycle and effectiveness of *Medetera aldrichii* as a predator of *Dendroctonus pseudotsugae*.

79. JANTZ, ORLO K., and RICHARD L. JOHNSEY. 1964. Determination of sex of the Douglas-fir beetle *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Scolytidae). Can. Entomol. 96:1327-1329.

Character of the elytral declivity proved to be the most satisfactory, rapid, and accurate method for sexing live Douglas-fir beetles.

80. JANTZ., O. K., and J. A. RUDINSKY. 1965. Laboratory and field methods for assaying olfactory responses of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins. Can. Entomol. 97:935-941.

The attraction produced by female beetles inserted into logs of several tree species was compared with a laboratory walkway and in the field. Frass extracts of all tree species arrested beetles in walkway tests but to varying degree. Western larch was the only host attacked outside the perimeter of attraction of infested Douglas-fir logs. Brood was established, in reduced numbers, within the perimeter of attraction in ponderosa pine, western hemlock, and western white pine, which are normally nonhosts. Grand fir logs were not attacked.

81. JANTZ, O. K., and J. A. RUDINSKY. 1966. Studies of the olfactory behavior of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins. Oreg. State Univ., Agric. Exp. Stn. Tech. Bull. 94, 38 p.

Logs containing virgin females were more attractive than tree volatiles, uninfested logs, or logs containing reemerged females. Of the host volatiles tested, 2½% resin, α-pinene, and limonene attracted the most beetles. Attraction suddenly decreased immediately after mating. Presents histological study of the gut and seasonal and diurnal flight.

82. JOHNSEY, R. L., W. P. AGEL, and J. A. RUDINSKY. 1965. The Diptera *Medetera aldrichii* Wheeler (Dolichopodidae) and *Lonchaea furnissi* McAlpine (Lonchaeidae) associated with the Douglas-fir beetle in western Oregon and Washington. Can. Entomol. 97:521-527.

Immature Douglas-fir beetles were preyed upon but the teneral adults were rarely attacked by third-instar larvae of *Medetera aldrichii*. Third-instar larvae of *Lonchaea furnissi* did not attack the beetles in any stage during laboratory studies. Emergence patterns from infested Douglas-fir and effects of temperature and light on emergence and flight are discussed.

83. JOHNSON, NORMAN E. 1960. Douglas-fir beetle: A problem analysis. Weyerhaeuser Co., For. Res. Note 29, 19 p. + appendix.

Reviews and references, by subject, the literature prior to 1960 and proposes a research program.

84. JOHNSON, NORMAN E. 1960. Reduction of risk of losses by the Douglas-fir beetle and ambrosia beetles: An interim guide. Weyerhaeuser Co., For. Res. Note 34, 8 p.

Recommends removal of windthrow, particularly that in shade, to prevent population buildup. Safest felling season to avoid Douglas-fir beetle is late summer; that to avoid ambrosia beetles is spring.

85. JOHNSON, NORMAN E. 1962. Rearing of Douglas-fir beetle broods in waxed slabs. Ann. Entomol. Soc. Am. 55:659-663.

Survival of beetle broods in waxed slabs was dependent on the degree of wax covering and width of the slab.

86. JOHNSON, NORMAN E. 1963. Factors influencing the "second-attack" of the Douglas-fir beetle--Progress 1960-1962. Weyerhaeuser Co., For. Res. Note 53, 14 p.

In laboratory experiments, moisture content of the sapwood was the determining factor for when beetles leave the first gallery and start constructing another. Field tests showed that second attacks did not peak, but were more or less continuous throughout the summer.

87. JOHNSON, NORMAN E. 1963. Effects of different drying rates and two insecticides on beetle attacks in felled Douglas-fir and western hemlock. Weyerhaeuser Co., For. Res. Note 58, 16 p.

Douglas-fir beetles attacked limbed, limbed and bucked, and unlimbed Douglas-fir (but not hemlock) equally. Brood survival was lowest in unlimbed trees that dried more rapidly. BHC and endosulfan insecticide treatments significantly reduced or eliminated Douglas-fir beetle attacks on test bole sections.

88. JOHNSON, NORMAN E. 1967. The influence of temperature and moisture on the overwintering mortality of the Douglas-fir beetle, *Dendroctonus pseudotsugae*, in Western Washington (Coleoptera: Scolytidae). Ann. Entomol. Soc. Am. 60:199-204.

In field and laboratory studies, "hardened-off" adults survived cold, wet conditions better than callow adults, pupae, or larvae.

89. JOHNSON, NORMAN E., and P. G. BELLUSCHI. 1969. Host-finding behavior of the Douglas-fir beetle. J. For. 67:290-295.

A case history is drawn from observation of an infestation following the Columbus Day storm of 1962. Beetles attacked injured trees (felled, broken off, or leaning over) and then spilled over into live surrounding trees. Gives suggestions to alleviate damage.

90. JOHNSON, NORMAN E., and MALCOLM M. FURNISS. 1967. Controlled breeding of the Douglas-fir beetle, *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae), from Idaho and coastal Washington. Ann. Entomol. Soc. Am. 60:31-33.

Crossmatings of beetles from Idaho and Washington produced fertile offspring, but in fewer numbers than did matings of beetles from a single locality.

91. JOHNSON, NORMAN E., and H. DAVID MOLATORE. 1961. X-ray detection of Douglas-fir beetles reared in slabs. Can. Entomol. 93:928-931.

Brood development in waxed slabs was traced reliably using X-ray detection in all stages except immature larvae.

92. JOHNSON, NORMAN E., P. W. ORR, and K. H. WRIGHT. 1959. Beetle hazard in windthrown Douglas-fir. Weyerhaeuser Timber Co., For. Res. Note 20, 3 p.

Shaded windthrow had more Douglas-fir beetle attacks and a higher percentage of brood survival than did exposed windthrow.

93. JOHNSON, NORMAN E., and LEON F. PETTINGER. 1961. Douglas-fir beetle attacks in living trees as influenced by the presence of fresh windthrow. Weyerhaeuser Co., For. Res. Note 37, 8 p.

All standing trees within 3 ft. of newly-downed trees were attacked in a 100-yr. old stand; attacks decreased as the distance from downed trees increased. Beetles were induced to attack other standing trees that had 1-ft. sections of uninfested, newly-cut Douglas-fir next to them.

94. JOHNSON, NORMAN E., and LEON F. PETTINGER. 1961. Overwintering mortality of Douglas-fir beetles in infested logs, exposed bark and forest litter in western Washington. Weyerhaeuser Co., For. Res. Note 42, 11 p.

Approximately one-half of adult beetles survived over winter in loose bark and forest litter. Larval survival was similar. Eighty-four percent of the beetles survived in undisturbed bark of windthrown trees.

95. JOHNSON, NORMAN E., K. H. WRIGHT, and P. W. ORR. 1961. Attack and brood survival by the Douglas-fir beetle in four types of windthrown trees in western Washington. Weyerhaeuser Co., For. Res. Note 40, 13 p.

Attacks and brood survival were highest in shaded windthrown trees.

96. KEEN, F. P. 1952. Insect enemies of western forests. USDA, Div. For. Insect Invest.. Bur. Entomol. and Plant Quar., Misc. Publ. 273:155-158.

Briefly discusses Douglas-fir beetle damage, biology, and control.

97. KHAN, M. A. 1957. *Sphaerularia bombi* Duf. (Nematoda: Allantonematidae) infesting bumblebees and *Sphaerularia hastata* sp. nov. infesting bark beetles in Canada. Can. J. Zool. 35:519-523.

Sphaerularia hastata infests adult Douglas-fir beetles in British Columbia.

98. KHAN, M. A. 1957. *Sphaerularia ungulacauda* sp. nov. (Nematoda: Allantonematidae) from the Douglas-fir beetle *Dendroctonus pseudotsugae* Hopk., with key to *Sphaerularia* species (Emended). Can. J. Zool. 35:635-639.

Describes *Sphaerularia ungulacauda* from adult Douglas-fir beetles in British Columbia.

99. KHAN, M. A. 1960. Descriptions of two nematodes, *Ektaphelenchus macrostylus* n. sp., and *Laimaphelenchus ulmi* n. sp., with a key to species of *Laimaphelenchus*. Can. J. Zool. 38:91-97.

Female *Ektaphelenchus macrostylus* were taken from Douglas-fir beetles; males were found in the bark of Douglas-fir.

100. KHAN, M. A. 1960. *Stictylus hastatus* (Khan 1957) n. comb., and *Stictylus ungulacaudus* (Khan 1957) n. comb. (Nematoda: Neotylenchidae). Can. J. Zool. 38:225-226.

Transfers these two nematode parasites of the Douglas-fir beetle from the genus *Sphaerularia* Dufour to the genus *Stictylus* Thorne.

101. KIMMEY, J. W., and R. L. FURNISS. 1943. Deterioration of fire-killed Douglas-fir. U.S. Dep. Agric. Tech. Bull. 851, 61 p.

Douglas-fir beetles are among the first insects to attack Douglas-fir killed by a fire, usually during the following spring. The beetle is important because it introduces fungi, including blue-stain, which speeds deterioration of the sapwood. Deterioration rate is discussed by causes, tree characteristics, and environmental factors.

102. KINGHORN, J. M. 1953. Chemical control of bark beetles. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 9(4):4.

Douglas-fir beetle was completely controlled by spraying infested logs with 0.8 lb. ethylene dibromide/gal. in a 20-percent oil emulsion.

103. KINGHORN, J. M. 1955. Chemical control of mountain pine beetle and Douglas-fir beetle. J. Econ. Entomol. 48:501-504.

Two systemic insecticides (Systox and schradan) and four bark sprays (ethylene dibromide, heptachlor, aldrin and lindane) were applied to trees and logs. Ethylene dibromide was most effective.

104. KINGHORN, J. M. 1957. An induced differential bark beetle attack. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 13(2):3-4.

Short sections cut from felled trees and then aged were not attacked by Douglas-fir beetles but longer stem pieces left in the woods were readily infested. Inverse results occurred with the striped ambrosia beetle.

105. KINGHORN, J. M., and W. WEBB. 1950. Chemical control of ambrosia beetles. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 6(6):3-4.

Benzene hexachloride in oil or as an emulsion spray significantly reduced Douglas-fir beetle attacks on test logs.

106. KINZER, G. W., A. F. FENTIMAN, JR., R. L. FOLTZ, and J. A. RUDINSKY. 1971. Bark beetle attractants: 3-methyl-2-cyclohexen-1-one isolated from *Dendroctonus pseudotsugae*. J. Econ. Entomol. 64:970-971.

3-methyl-2-cyclohexen-1-one was extracted and identified from hindguts of female Douglas-fir beetles. Greater numbers of walking male beetles were arrested by the compound in mixture with frontalin than by either frontalin or the compound alone. Frontalin was identified from female hindguts, and three other biologically active compounds also were isolated.

107. KLINE, L. N., and J. A. RUDINSKY. 1964. Predators and parasites of the Douglas-fir beetle: Description and identification of the immature states. Oreg. State Univ., Agric. Exp. Stn. Tech. Bull. 79, 52 p.

Describes eggs, larval instars, and pupae of principal predators and parasites. Discusses rearing procedures and measurement and drawing methods.

108. KNOPF, J. A. E., and G. B. PITMAN. 1972. Aggregation pheromone for manipulation of the Douglas-fir beetle. J. Econ. Entomol. 65:723-726.

Douglure (a mixture of frontalin, α-pinene and camphene) in polyethylene containers was applied to 157 live Douglas-fir trees. By June 25, all treated trees, but only 8 percent of the control trees, were attacked. Attack density was 12+/sq.ft. Within 33 ft. of baited trees, 58 percent of the Douglas-fir were attacked, as compared to 4 percent surrounding control trees. Beetles attacked proportionately more of the large trees surrounding the treated trees. The average infested height of treated trees was 36 percent shorter than that of control trees.

109. LeJEUNE, R. R., L. H. McMULLEN, and M. D. ATKINS. 1961. The influence of logging on Douglas-fir beetle populations. For. Chron. 37:308-314.

Beetle outbreaks can be prevented by measures designed to minimize presence of breeding material; logging of overmature stands; and cutting in a manner designed to trap and remove beetles.

110. LINDQUIST, EVERT E. 1969. Mites and the regulation of bark beetle populations. Second Int. Congr. Acarol. Proc., 1967:389-399.

Indicates that the egg predator, *Seius safroi* Ewing [see Bedard 1937] is currently *Lasioseius safroi* (Ewing) (= *dendroctoni* Chant). Other predacious or parasitic species associated with the Douglas-fir beetle are *Digamasellus* sp., *Proctolaelaps hystricoides* Lind. & Hunter, and *P. subcorticalis* Lind.

111. LINDQUIST, EVERT E. 1971. New species of Ascidae (Acarina: Mesotigmata) associated with forest insect pests. Can. Entomol. 103:919-942.

Douglas-fir beetle is mentioned as one host for *Proctolaelaps subcorticalis* Lind. in British Columbia.

112. LU, K. E., DONALD G. ALLEN, and WALTER B. BOLLEN. 1957. Association of yeasts with the Douglas-fir beetle. For. Sci. 3:336-343.

Cultured yeasts from beetles were identified as *Saccharomyces pastoria*, *Candida parapsilosis*, *C. mycoderma*, and *Hensenula capsulata*. When presented to live beetles, odors of the four yeasts combined and of *S. pastoria* alone evoked positive response; beetles rejected *C. parapsilosis* and *C. mycoderma* (each alone) in favor of the control arm of the olfactometer.

113. LYON, R. L. 1958. A useful secondary sex character in *Dendroctonus* bark beetles. Can. Entomol. 90:582-584.

The sex of *Dendroctonus* beetles can be readily and accurately determined by the shape of the seventh abdominal tergite.

114. LYON, ROBERT L. 1965. Structure and toxicity of insecticide deposits for control of bark beetles. USDA For. Serv. Tech. Bull. 1343, 59 p.

Reviews results of spray tests conducted on bark beetles including the Douglas-fir beetle.

115. McALPINE, J. F. 1964. Descriptions of new Lonchaeidae (Diptera). II. Can. Entomol. 96:701-757.

Describes *Lonchaea furnissi*, which is associated with Douglas-fir beetle egg galleries; it occurs in Idaho, Oregon, Washington, and British Columbia.

116. McCOWAN, V. F., and JULIUS A. RUDINSKY. 1958. Biological studies on the Douglas-fir bark beetle, Millicoma Forest, Coos Bay, Oregon. Weyerhaeuser Timber Co., For. Res. Note 14, 21 p. (Rev.)

Contains important information on seasonal history, sampling, distribution of brood and attacks in standing trees and in windthrow trees, natural enemies, amount of mortality by stem position and time, relation of growth to susceptibility, and associated insects and fungi.

117. McGHEHEY, J. H., and W. P. NAGEL. 1966. A technique for rearing larvae of *Medetera aldrichii* (Diptera: Dolichopodidae). Ann. Entomol. Soc. Am. 59:290-292.

A study of four media to develop a suitable technique for rearing the larval stages of *Medetera aldrichii* on its host *Dendroctonus pseudotsugae*. Douglas-fir phloem mixture was the only successful medium.

118. McMULLEN, L. H. 1956. A note on the mortality of the Douglas-fir beetle in the interior of British Columbia during the winter of 1955-56. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 12(6):3-4.

Callow adult mortality of nearly 75 percent seemed to be caused by sudden severe cold weather in early November.

119. McMULLEN, L. H. 1970. Extended life cycle of Douglas-fir beetle in interior British Columbia. Can. Dep. Fish. and For., For. Serv., Bimon. Prog. Rep. 26(5):46.

A report of two instances in which brood remained in trees for 2 years.

120. McMULLEN, L. H. and M. D. ATKINS. 1959. A portable tent-cage for entomological field studies. Entomol. Soc. B.C. Proc. 56(4):67-68.

Describes a tent-cage of nylon netting, 6 ft. long with 4 ft. wide floor and sides, used to study Douglas-fir beetles in logs under field conditions.

121. McMULLEN, L. H., and M. D. ATKINS. 1961. Intraspecific competition as a factor in the natural control of the Douglas-fir beetle. For. Sci. 7:197-203.

As crowding increased, parents abandoned their egg galleries more rapidly; egg galleries were shorter, contained fewer eggs, and mortality of larvae and pupae was higher. Maximum absolute production of adult brood occurred at attack densities of 4-8/sq.ft. Relative increase in progeny per parent was inversely proportional to attack density; it declined to 1:1 at 13-17 attacks/sq.ft.

122. McMULLEN, L. H., and M. D. ATKINS. 1962. On the flight and host selection of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. (Coleoptera: Scolytidae). Can. Entomol. 94:1309-1325.

Beetles flew in spring when temperatures reached 65 to 70° F. for a few days. Newly-felled trees were more attractive than trees felled 15 days or more. At high temperature, attacks were heavier on the underside. Initial attack by females created a strong attraction, which increased with number of females present. Presence of males in galleries reduced attractiveness.

123. McMULLEN, L. H., and J. WALTERS. 1956. Transplanting larvae of *Dendroctonus pseudotsugae* Hopk. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 12(3):3-4.

Larvae were transplanted from brood logs to holes made in uninfested logs. Survival was 4-40 and 50-100 percent in punched and chiseled holes, respectively.

124. MASSEY, CALVIN L. 1966. The genus *Mikoletzkya* (Nematoda) in the United States. Helminthol. Soc. Wash. Proc. 33:13-19.

Contains description of *Mikoletzkya diluta* associated with the Douglas-fir beetle.

125. MASSEY, CALVIN L. 1967. Nematodes associated with tree-infesting insects: Paurondontidae new family and Misticiinae new subfamily with a description of one new genus and four new species. Can. J. Zool. 45:779-786.

Misticius mustus was recovered from Douglas-fir beetle galleries in New Mexico.

126. MASSEY, CALVIN L. 1969. New species of tylenchs associated with bark beetles in New Mexico and Colorado. Helminthol. Soc. Wash. Proc. 36:43-52.

Describes the nematode *Neoditylenchus puniwopus* in association with Douglas-fir beetles from New Mexico.

127. MATHERS, W. G. 1951. Douglas-fir beetle [in British Columbia]. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 7(3):3.

In a 250-year-old stand, susceptibility was correlated with slow growth and injury (including windthrow) but not dominance or size.

128. MICHAEL, R. R., and J. A. RUDINSKY. 1972. Sound production in Scolytidae: Specificity in male *Dendroctonus* beetles. J. Insect Physiol. 18:2189-2201.

The male stridulatory apparatus (pars stridens on the left elytron and plectum on the seventh abdominal tergite) was measured and described from scanning electron micrographs. Sound properties of "chirps" were analyzed for number, rate, and duration of tooth strikes. Chirps were evoked using either the natural female attractant (frass) or four synthetic components. Compared to the mountain pine beetle, the sounds made by the Douglas-fir beetle were species specific.

129. PITMAN, G. B. 1973. Further observations on douglure in a *Dendroctonus pseudotsugae* management system. Environ. Entomol. 2:109-112.

Douglure applied to trees singly and in groups resulted in attacks on 67.1 and 68.5 percent, respectively, of the trees within 1 chain distance. Height of attacks was less in baited trees than in surrounding attacked trees. Sticky boards, containing Douglure, entrapped only 8.6 Douglas-fir beetles/sq.ft. One *Thanasimus undatulus* was caught per bark beetle.

130. PITMAN, G. B., and J. P. VITE. 1970. Field response of *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae) to synthetic frontalin. Ann. Entomol. Soc. Am. 63:661-664.

Among 7 treatments, frontalin plus camphene attracted the most beetles (4♂:1♀) and large numbers of the clerid *Thanasimus undatulus* Say. Frontalin induced attack when applied to live trees. Frontalin appeared in female hindguts within 24 hr. after feeding and disappeared by 48 hr.

131. RENWICK, J. A. A., and J. P. VITÉ. 1968. Isolation of the population aggregating pheromone of the southern pine beetle. Contrib. Boyce Thompson Inst. 24(4):65-68.

Gas chromatography showed that female Douglas-fir beetles have a compound in common with the female southern pine beetle and male western pine beetle. In field tests, crushed, emerged female Douglas-fir beetles attracted southern pine beetles.

132. RICHERSON, J. V., and J. H. BORDEN. 1971. Sound and vibration are not obligatory host finding stimuli for the bark beetle parasite, *Coeloides brunneri* (hymenoptera: Braconidae). Entomophaga 16:95-99.

Coeloides brunneri discerned different stages of host beneath the surface of Douglas-fir beetle-infested logs and oviposited through bark only onto older larvae. The parasite was also able to locate and oviposit on larvae that had been freeze-killed.

133. RICHERSON, J. V., and J. H. BORDEN. 1972. Host finding behavior of *Coeloides brunneri* (Hymenoptera: Braconidae). Can. Entomol. 104:1235-1250.

Describes four distinct phases of host finding: random search; nonrandom search; ovipositional; and nonsearch (resting and cleaning). Amputation showed that the antennae are the principal host-finding receptor organs. Sounds, magnetism, and odor were not involved in host finding.

134. RICHERSON, J. V., and J. H. BORDEN. 1972. Host finding by heat perception in *Coeloides brunneri* (Hymenoptera: Braconidae). Can. Entomol. 104:1877-1881.

Coeloides brunneri females were shown to oviposit at warmer locations on bark. These "hotspots" were associated with subcortical Douglas-fir beetle larvae. When a heated wire was inserted in bark, oviposition behavior was induced. The evidence supports the argument that *C. brunneri* locates its host through perception of infrared radiation.

135. RICHERSON, J. V., J. H. BORDEN, and J. HOLLINGDALE. 1972. Morphology of a unique sensillum placodeum on the antennae of *Coeloides brunneri* (Hymenoptera: Can. J. Zool. 50:909-914.

Describes a unique antennal placoid sensillum; its anatomy suggests that it directs infrared radiation during location of host larvae such as the Douglas-fir beetle.

136. ROSS, D. A. 1967. Wood and bark-feeding Coleoptera of felled western larch in British Columbia. J. Entomol. Soc. B.C. 64:23-24.

Includes Douglas-fir beetle in a list of Coleoptera reared from western larch.

137. RUDINSKY, J. A. 1961. Factors affecting the population density of bark beetles. Thirteenth Congr. Int. Union For. Res. Organ., Vienna, Proc. I: Sec. 24-11, 13 p.

Biotic factors affecting Douglas-fir beetle abundance include intraspecific competition and entomophages. Moisture affects resin pressure that is $<1\frac{1}{2}$ atm. in susceptible trees. Susceptible trees also are invaded more rapidly by blue stain fungi and have low pH.

138. RUDINSKY, J. A. 1962. Ecology of Scolytidae. Annu. Rev. Entomol. 7:327-348.

The Douglas-fir beetle is referred to somewhat incidentally and for illustrative purposes in this broad review of scolytid ecology.

139. RUDINSKY, J. A. 1963. Response of *Dendroctonus pseudotsugae* Hopkins to volatile attractants. Contrib. Boyce Thompson Inst. 22:23-38.

Attraction of flying beetles resulted only from virgin female beetles feeding in phloem. The attractive substance was present in frass and excrement and was soluble in petroleum ether. Response of beetles to field olfactometers baited with logs infested with females exhibited a distinct diurnal and seasonal pattern influenced by environmental factors, mainly temperature.

140. RUDINSKY, J. A. 1966. Host selection and invasion by the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins, in coastal Douglas-fir forests. Can. Entomol. 98:98-111.

More females than males respond to odors of volatile terpenes in resin, which provide primary (host) attraction to flying beetles. Trees of insufficient oleoresin exudation pressure (OEP) are invaded successfully by females, which creates a secondary attraction and results in mass concentration (favoring males) of additional beetles. However, trees having high OEP resist attacking beetles either by repelling them with concentrated vapors or by suffocating them.

141. RUDINSKY, J. A. 1966. Observations on olfactory behavior of scolytid beetles (Coleoptera: Scolytidae) associated with Douglas-fir forests. Z. Angew. Entomol. 58(4):356-361.

In the field, Douglas-fir beetles were attracted to logs containing females, in a ratio of 3 males to 1 female. Ethanol extract from female frass was more attractive than uninfested logs. Attractive host volatiles were camphene, resin, α-pinene and limonene.

142. RUDINSKY, JULIUS A. 1966. Scolytid beetles associated with Douglas-fir: response to terpenes. Science 152:218-219.

Response of Douglas-fir beetle (and other scolytids) to host volatiles was studied. Most attractive in the following order were camphene, resin, α-pinene, limonene, and logs. Responding females outnumbered males 2:1.

143. RUDINSKY, J. A. 1968. Pheromone-mask by the female *Dendroctonus pseudotsugae* Hopk., an attraction regulator (Coleoptera: Scolytidae). Pan-Pac. Entomol. 44:248-250.

Male stridulation or mating resulted in cessation of attraction created by females in bark. Attraction was reestablished within 10 min. by removal of stridulating males from close proximity to unmated females. The mask was restricted to the area near the female entry hole; thus it permitted colonization of uninfested parts of the host tree.

144. RUDINSKY, J. A. 1969. Masking of the aggregation pheromone in *Dendroctonus pseudotsugae* Hopk. Science 166:884-885.

Attraction created by virgin females feeding in phloem was masked suddenly by male stridulation. Attack density is thereby regulated without disrupting the mating of the arrested male.

145. RUDINSKY, J. A. 1969. Studies on timber beetles. P. 64-65 in: Insect-plant Interactions, Nat. Acad. Sci., Wash., D. C.

Mentions chemical studies underway on the pheromone of *Dendroctonus pseudotsugae*.

146. RUDINSKY, J. A. 1970. Sequence of Douglas-fir beetle attraction and its ecological significance. Contrib. Boyce Thompson Inst. 24:311-314.

Flying female beetles were attracted weakly to host tree volatiles in a ratio favoring females. As the females bored into the bark, they produced pheromones that created a strong secondary attraction favoring males. Male stridulation at a gallery entry stimulated the female to release a short-range masking substance that abruptly terminated the attractiveness to other males. However, this mask did not deter the stridulating male nor terminate primary attraction.

147. RUDINSKY, J. A., and G. E. DATERMAN. 1964. Field studies on flight patterns and olfactory responses of ambrosia beetles in Douglas-fir forests of western Oregon. Can. Entomol. 96:1339-1352.

Gnathotrichus sulcatus Lec. and *G. retusus* Lec. were strongly attracted to logs infested with female Douglas-fir beetles; *Trypodendron lineatum* (Oliv.) was not attracted.

148. RUDINSKY, J. A., M. M. FURNISS, L. N. KLINE, and R. F. SCHMITZ. 1972. Attraction and repression of *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae) by three synthetic pheromones in sticky traps in Oregon and Idaho. Can. Entomol. 104:815-822.

The attractiveness of frontalin and host volatiles was confirmed but addition of 3-methyl-2-cyclohexen-1-one disrupted attraction and reduced by up to 96 percent the number of beetles caught. Males were repressed more than females. The role of *trans*-verbenol was not clear.

149. RUDINSKY, J. A., G. W. KINZER, A. F. FENTIMAN, JR., and R. L. FOLTZ. 1972. *Trans*-verbenol isolated from Douglas-fir beetle: laboratory and field bioassays in Oregon. Environ. Entomol. 1:485-488.

Trans-verbenol decreased to nil after 48 hr. in female beetles from Idaho, but still was detectable after 72 hr. in Oregon beetles. In the laboratory, arrestment of walking beetles increased with lower concentration of *trans*-verbenol. In the field, flying beetles were arrested only if frontalin also was present.

150. RUDINSKY, J. A., and R. R. MICHAEL. 1972. Sound production in Scolytidae: Chemostimulus of sonic signal by the Douglas-fir beetle. Science 175:1386-1390.

Almost all males stridulated in response to female-produced frass but up to 88 percent also responded to combinations of synthetic pheromones and host tree volatiles. Female attraction ceased abruptly when subjected to the sound of a live stridulating beetle or to a recording of the sound.

151. RUDINSKY, J. A., and R. A. MICHAEL. 1973. Sound production in Scolytidae: Stridulation by female *Dendroctonus* beetles. J. Insect. Physiol. 19:689-705.

Female beetles possess stridulatory apparatus on the last sternite and inside the top of the left elytron (similar to males). Solitary females emit an infrequent click whereas rapid clicks or multiple chirps are evoked by close proximity of other females of the same species. These sounds may regulate attack spacing.

152. RUDINSKY, J. A., and PAVEL SVIHRA. 1971. The patterns of water ascent in conifers. Acta Inst. For., Zvolen, Czech. II:369-383.

[Deals mainly with five patterns of ascent found in conifers.] Water ascends in Douglas-fir in a sectorial, winding manner. This pattern allows a large lateral portion of a growth ring to be supplied from each and enables the tree to restore water balance quickly during rainy weather. Restoration of water balance results in resinosis, which repels beetles and prevents spread of blue stain fungi.

153. RUDINSKY, J. A., and L. C. TERRIERE. 1959. Laboratory studies on the relative contact and residual toxicity of ten test insecticides to *Dendroctonus pseudotsugae* Hopk. J. Econ. Entomol. 52:485-488.

Lindane at LD 50 and Thiodan at LD 90 were most toxic but DDT lasted longest of all insecticides that were applied to a wood fiber surface.

154. RUDINSKY, J. A., L. C. TERRIERE, and D. G. ALLEN. 1960. Effectiveness of various formulations of five insecticides on insects infesting Douglas-fir logs. J. Econ. Entomol. 53:949-953.

Emulsions and solutions of endrin, lindane, Thiodan, Sevin and heptachlor protected logs from Douglas-fir beetle attack. In the laboratory, suspensions were less effective on logs but had higher residual toxicity on wood fiber surfaces.

155. RUDINSKY, J. A., and J. P. VITÉ. 1956. Effects of temperature upon the activity and the behavior of the Douglas-fir beetle. For. Sci. 2:258-267.

Reports on a study of relationships of temperature to limits of beetle activity, boring rate, flight (duration, velocity), and running; and reactions to light.

156. RUDINSKY, J. A., and O. ZETHNER-MØLLER. 1967. Olfactory responses of *Hylastes nigrinus* (Coleoptera: Scolytidae) to various host materials. Can. Entomol. 99: 911-916.

Flying *H. nigrinus* were strongly attracted to stumps of trees killed by the Douglas-fir beetle.

157. RUMBOLD, CAROLINE T. 1936. Three blue-staining fungi, including two new species, associated with bark beetles. J. Agric. Res. 52:419-437.

Describes *Ceratostomella pseudotsugae*, a blue-stain fungus associated with Douglas-fir beetle.

158. RUST, H. J. 1933. Many bark beetles destroyed by predacious mite. J. Econ. Entomol. 26:733-734.

Refers to an instance in which 62.5 percent of Douglas-fir beetle eggs died, presumably caused mainly by mites.

159. RYAN, ROGER B. 1959. Termination of diapause in the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Scolytidae), as an aid to continuous laboratory rearing. Can. Entomol. 91:520-525.

New adult beetles undergo an obligatory diapause, during which they are incapable of either flight or reproduction. This condition is reflected by undeveloped main flight muscles and gonads. Diapause was broken [as indicated by emergence] most effectively by 90 days' exposure to 39-49° F., followed by rearing at 75° F. A generation was completed in a minimum of 146 days.

160. RYAN, R. B. 1962. Durations of the immature stadia of *Coeloides brunneri* (Hymenoptera: Braconidae) at various constant temperatures, with descriptions of the five larval instars. Ann. Entomol. Soc. Am. 55:403-409.

Reports on the duration of immature stadia at various temperatures and describes the five larval instars.

161. RYAN, ROGER B. 1962. A device for measuring the oviposition potential of a bark beetle parasite. Can. Entomol. 94:137-138.

Describes construction and use of a device to determine the percentage of log circumference where bark thickness is less than the mean ovipositor length of *Coeloides brunneri* Vier.

162. RYAN, ROGER B. 1965. Maternal influence on diapause in a parasitic insect, *Coeloides brunneri* Vier. (Hymenoptera: Braconidae). J. Insect Physiol. 11: 1331-1336.

Diapause of progeny was determined by the photoperiod and temperature to which parent females were exposed.

163. RYAN, ROGER B., and JULIUS A. RUDINSKY. 1962. Biology and habits of the Douglas-fir beetle parasite, *Coeloides brunneri* Viereck (Hymenoptera: Braconidae), in western Oregon. Can. Entomol. 94:748-763.

Comprehensively describes seasonal history; behavior during mating; searching and oviposition; host size and its influence on sex of progeny; longevity; oöcyte maturation and fecundity; and relationship between parasitism and bark thickness. A plan is proposed for manipulating the parasite to control the beetle.

164. SAHOTA, T. S. 1970. Haemolymph and ovarial proteins in the bark beetle, *Dendroctonus pseudotsugae* in relation to ovarian development. Can. J. Zool. 48:1307-1312.

Two female-specific blood proteins increased to a maximum 48 hr. after infestation of logs. Their incorporation into ovaries lagged by about 24 hr.; possibly, this is controlled by concentration of juvenile hormone.

165. SAHOTA, T. S. 1971. Failure of ovarian development in the Douglas-fir bark beetle, *Dendroctonus pseudotsugae*; an analysis of gut proteases and female-specific proteins. Can. J. Zool. 49:1021-1024.

Although provided suitable diet, female beetles that are outside their normal gallery environment fail to reproduce. Study indicates that proteolytic enzymes in guts of females are adequate and that lack of juvenile hormone may be responsible for absence of ovarian development.

166. SAHOTA, T. S., J. A. CHAPMAN, and W. W. NIJHOLT. 1970. Ovary development in a scolytid beetle *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae): Effect of farnesyl methyl ether. Can. Entomol. 102:1424-1428.

Ovarian development was stimulated naturally by introduction of females to logs, or unnaturally stimulated by treatment with the gonadotrophic hormone, =farnesyl methyl ether.

167. SCHMIDT, FRED H. 1966. Two artificial (oligidic) media for the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. (Coleoptera: Scolytidae). Can. Entomol. 98:1050-1055.

Under xenic conditions, both media shortened the rate of brood development compared to previous published data. Adults appeared to be normal; females laid viable eggs.

168. SCHMITZ, RICHARD F., and JULIUS A. RUDINSKY. 1968. Effect of competition on survival in western Oregon of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Scolytidae). Oreg. State Univ. For. Res. Lab., Res. Pap. 8, 42 p.

In controlled laboratory and field tests, intraspecific competition decreased survival when densities exceeded 2 attacks, 50-100 larval mines, or 19 inches of egg gallery per sq.ft. Interspecific competition was not a factor in natural control.

169. SCHOFER, G. A., and G. N. LANIER. 1970. A sexual character in pupae of *Dendroctonus* (Coleoptera: Scolytidae). Can. Entomol. 102:1487-1488.

Though Douglas-fir beetle pupae were not examined, a lobe between the 8th sternite and 9th tergite is present in females but absent in males of several *Dendroctonus* species; this is suggested as a possible generic character.

170. SMITH, H. W., and M. M. FURNISS. 1966. An automatically recording insect flight mill. Can. Entomol. 98:249-252.

Describes specifications and instructions for an automatically recording insect flight mill. Revolutions of individual flight mills are recorded, by photocells, on electric counters.

171. SMYTH, ARTHUR V. 1959. The Douglas-fir bark beetle epidemic on the Millicoma Forest: Methods used for control and salvage. J. For. 57:278-280.

Because of deterioration, timber must be salvaged within 10 years after being killed by beetles. Systematic survey and maintenance of access roads are necessary if prompt sanitation cutting and salvage are to be effective.

172. STOSZEK, K. J., and J. A. RUDINSKY. 1967. Injury of Douglas-fir trees by maturation feeding of the Douglas-fir Hylesinus, *Pseudohylesinus nebulosus* (Coleoptera: Scolytidae). Can. Entomol. 99:310-311.

Pseudohylesinus nebulosus feeding may be a contributing factor to Douglas-fir beetle attacks on shealthy trees.

173. THOMAS, J. B. 1965. The immature stages of Scolytidae: The genus *Dendroctonus* Erichson. Can. Entomol. 97: 374-400.

Provides keys and illustrations for separating larvae and pupae of *Dendroctonus* species. *D. pseudotsugae* larvae differ from *D. simplex* in size, roughness of frons,

and basal part of the mandibles. Pupae display differences in the setae on the body and head.

174. THOMAS, J. B. 1967. A comparative study of gastic caeca in adult and larval stages of bark beetles (Coleoptera: Scolytidae). Entomol. Soc. Ont. Proc. 97(1966):71-90.

Describes and compares caeca on the midgut of Douglas-fir beetle larvae and adults to other *Dendroctonus*.

175. THOMPSON, S. N., and R. B. BENNETT. 1971. Oxidation of fat during flight of male Douglas-fir beetles, *Dendroctonus pseudotsugae*. J. Insect Physiol. 17: 1555-1563.

Flying male beetles utilized predominantly fatty acids, particularly monosaturates followed by saturates.

176. VITÉ, J. P. 1968. Timber industry attacks bark beetle problem through basic research. Tex. Ind. 36(Sept.):14-16.

Large quantities of frontalin were found in female *Dendroctonus pseudotsugae*.

177. VITÉ, J. P. 1970. Erste Anwendung synthetischer Populationslockstoffe in der Borkenkäferbekämpfung. Allg. Forstz. 25:615-616.

Research at Boyce Thompson Institute has led to the discovery of frontalin as a principal population-aggregating pheromone of *Dendroctonus pseudotsugae*.

178. VITÉ, J. P. 1970. Pest management systems using synthetic pheromones. Contrib. Boyce Thompson Inst. 24:343-350.

Advocates baiting live Douglas-fir trees, within blocks of timber to be clearcut, with frontalin, α-pinene, and camphene.

179. VITÉ, J. P., G. B. PITMAN, A. F. FENTIMAN, JR., and G. W. KINZER. 1972. Die Naturwissenschaften 10:469-470.

The bicyclic ketal 3-methyl-2-cyclohexen-1-ol was theoretically predicted to be a possible attractant for *D. pseudotsugae*. Its natural presence in that beetle as well as *D. rufipennis* (Kirby) was confirmed by chemical analyses.

180. VITÉ, J. P., and J. A. RUDINSKY. 1957. Contribution toward a study of Douglas-fir beetle development. For. Sci. 3:156-167.

Describes characteristics, including larval head widths, of all stadia and their duration at different temperatures. The characteristics of the ovaries are shown in relation to age and reproductive history. Some males demonstrated that they were polygamous.

181. VITÉ, J. P., and J. A. RUDINSKY. 1962. Investigations on the resistance of conifers to bark beetle infestation. XI Int. Kongr. Entomol., Wien 1960. Sonderdr. Verh. II:219-225.

Oleoresin exudation pressure (o.e.p.) in Douglas-fir reaches equilibrium more slowly and is less than in ponderosa pine. Pressure is lowest during intensive growth, in trees infected by the fungus *Fomes pini* (Thore) Lloyd, and in windthrown trees.

182. WALTERS, H., and K. GRAHAM. 1952. The Douglas-fir beetle problem in the interior of British Columbia. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 8(5):3.

Twenty-three infestations (10-350 trees each) were examined. Beetle infestations usually were found where logging operations had produced excess slash and in overmature stands.

183. WALTERS, J. 1955. Douglas-fir beetle associated with winter injury. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 11(4):2-3.

In old-growth Douglas-fir stands, tree mortality increased rapidly after winter injury.

184. WALTERS, J. 1956. Biology and control of the Douglas-fir beetle in the interior of British Columbia. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Publ. 975, 11 p.

Describes life history and habits of the beetle; also discusses practices to prevent and control outbreaks.

185. WALTERS, J., and D. K. CAMPBELL. 1955. Mites as agents of natural control of the Douglas-fir beetle. Can. Dep. Agric., For. Biol. Div. Sci. Serv., Bimon. Prog. Rep. 11(1):3-4.

Logs were infested with 109 mite-free and 124 mite-infested beetles. Reduction of brood (presumably by mites) averaged 26 percent. Predation was considerably less on second brood of reemerged parents. Species involved were *Calvolia* sp., *Dendrolaelaps quadrisetis* (Berl.), *Lasioseius* sp., *Parasitus* sp., and *Uropoda* sp., prob. *michiganensis* Vitz.

186. WALTERS, J., and L. H. McMULLEN. 1956. Life history and habits of *Pseudohylesinus nebulosus* (Leconte) (Coleoptera: Scolytidae) in the interior of British Columbia. Can. Entomol. 88:197-202.

P. nebulosus is the first bark beetle to infest felled Douglas-fir trees in the spring. Attacks average 51/sq.ft. (max. 122). Infested bark may be unsuitable for attacks by the Douglas-fir beetle. An average of 18 eggs are laid per gallery (max. 43). Larvae have three instars. One generation occurs per year; young adults overwinter in niches in bark.

187. WEAR, J. F., and J. R. DILWORTH. 1955. Color photos aid salvage of beetle-killed Douglas-fir timber as mapping technique is developed. Lumberman 82:88-89,132-133.

Color photos greatly facilitated the location of infestations to help in planning logging operations. Comparison of ground and photocounts showed that some intermediate trees and most suppressed trees will be missed in photocounts. Compares advantages and disadvantages of aerial color transparencies to black and white photography, including cost.

188. WEAR, J. F., and P. G. LAUTERBACH. 1956. Color photographs useful in evaluating mortality of Douglas-fir. Soc. Am. For. Proc. 1955:169-171.

Aerial color photos greatly aided evaluation of mortality caused by the Douglas-fir beetle. Nearly twice as many errors occurred when interpreting panchromatic prints as compared to color. Use of color transparencies also facilitated location of recently-killed trees.

189. WEAR, J. F., R. B. POPE, and P. G. LAUTERBACH. 1962. Estimating beetle-killed Douglas-fir by aerial photo and field plots. J. For. 62:309-315.

A large number of color photoplots combined with ground-checking a small number of field plots proved to be a reliable and economical method to estimate beetle damage.

190. WEAR, J. F., R. B. POPE, and P. W. ORR. 1966. Aerial photographic techniques for estimating damage by insects in western forests. USDA For. Serv. Pac. Northwest For. and Range Exp. Stn. 79 p.

Presents sampling methods using aerial photos to estimate (a) amount of Douglas-fir beetle damage and (b) its location for salvage. Gives recommendations for film and scale.

191. WEISER, JAROSLAV. 1970. Three new pathogens of the Douglas fir beetle, *Dendroctonus pseudotsugae: Nosema dendroctoni* n.sp., *Ophryocystis dendroctonis* n.sp., and *Chytridiopsis typographi* n. comb. J. Invert. Pathol. 16:436-441.

The respectively named protozoan parasites generally occurred at low rates in malpighian tubules, fat bodies, some muscles; malpighian tubules; and epithelial cells of the midgut. The fungus, *Beauvaria bassiana*, infected dead adult beetles.

192. WERT, STEVEN L., and BRUCE ROETTGERING. 1968. Douglas-fir beetle survey with color photos. Photogramm. Eng. 34:1243-1248.

Large-scale (1:8,000) aerial photos combined with stratified 2-stage probability sampling proved to be the best survey technique in terms of accuracy, time required, and costs to determine the extent of damage from beetles in northwestern California.

193. WILLIAMSON, RICHARD L., and FRANK E. PRICE. 1971. Initial thinning effects in 70- to 150-year-old Douglas-fir--western Oregon and Washington. USDA For. Serv. Res. Pap. PNW-117, 15 p.

Thinning reduced tree mortality caused by bark beetles.

194. WOOD, STEPHEN L. 1963. A revision of the bark beetle genus *Dendroctonus* Erichson (Coeloptera: Scolytidae). Great Basin Nat. 23(1-2):117 p.

Includes description of physical characteristics and biology of the Douglas-fir beetle.

195. WOODRING, J. P. 1966. North American Tyroglyphidae (Acari): I. New species of *Calvolia* and *Nanacarus*, with keys to the species. La. Acad. Sci. Proc. 29:76-84.

Describes *Calvolia furnissi*, a mite taken from galleries and frass of Douglas-fir beetle near Moscow, Idaho.

196. WOODRING, J. P. 1966. North American Tyroglyphidae (Acari): II. The genus *Schwiebia*, with descriptions of four new species. La. Acad. Sci. Proc. 29:85-112.

Describes a mite, *Schwiebia pseudotsuga*, found in galleries of Douglas-fir beetles from Moscow, Idaho.

197. WOODRING, J. P., and J. C. MOSER. 1970. Six new species of anoetid mites associated with North American Scolytidae. Can. Entomol. 102:1237-1257.

Bonomoia certa was associated with Douglas-fir beetles from Moscow Mountain, Idaho.

198. WRIGHT, ERNEST, and K. H. WRIGHT. 1954. Deterioration of beetle-killed Douglas-fir in Oregon and Washington. A study of findings to date. U.S. For. Serv., Pac. Northwest For. and Range Exp. Stn. Res. Pap. 10, 12 p.

Describes study of decay rate in relation to tree age, ratio of sapwood to heartwood, wood borers, and intensity of beetle attack.

199. WRIGHT, K. H., and G. M. HARVEY. 1967. The deterioration of beetle killed Douglas-fir in western Oregon and Washington. U.S. For. Serv. Res. Pap. PNW-50, 20 p.

This report relates wood deterioration rate to tree age and size, external tree characters, causal agent (fungus, insect), and felling breakage.

200. WRIGHT, K. H., and P. G. LAUTERBACH. 1958. A 10-year study of mortality in a Douglas-fir sawtimber stand in Coos and Douglas Counties, Oregon. U.S. For. Serv., Pac. Northwest For. and Range Exp. Stn. Res. Pap. 27, 29 p.

Douglas-fir beetles accounted for 59 percent of tree mortality, followed by wind and disease. Mortality was greatest in codominant trees and on better sites.

201. WRIGHT, K. H., and R. R. LeJEUNE. 1967. Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. P. 16-20, in: Important Forest Insects and Diseases of Mutual Concern to Canada, the United States and Mexico. Can. Dep. For. & Rural Dev., 248 p.

Summarizes damage, distribution, life history, and control.

202. ZETHNER-MØLLER, O., and J. A. RUDINSKY. 1967. On the biology of *Hylastes nigrinus* (Coleoptera: Scolytidae) in western Oregon. Can. Entomol. 99:897-911.

H. nigrinus infests the roots of trees killed by Douglas-fir beetles. Competition with Douglas-fir beetle brood is slight.

203. ZETHNER-MØLLER, O., and J. A. RUDINSKY. 1967. Studies on the site of sex pheromone production in *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae). Ann. Entomol. Soc. Am. 60:575-582.

Describes the digestive tract, malpighian tubes, and reproductive system of females. Arrestment tests using these organs from attractive females indicate that the hindgut and malpighian tubes are associated with pheromone production.

SUBJECT INDEX

AUTHOR INDEX

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)

Back cover: A group of mature trees killed by Douglas-fir beetles.